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High-Resolution 3D Acoustic Borehole Integrity Monitoring System



Cristian Pantea – Los Alamos National Laboratory



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March 25, 2019



Solutions for Today | Options for Tomorrow



Technical Objectives

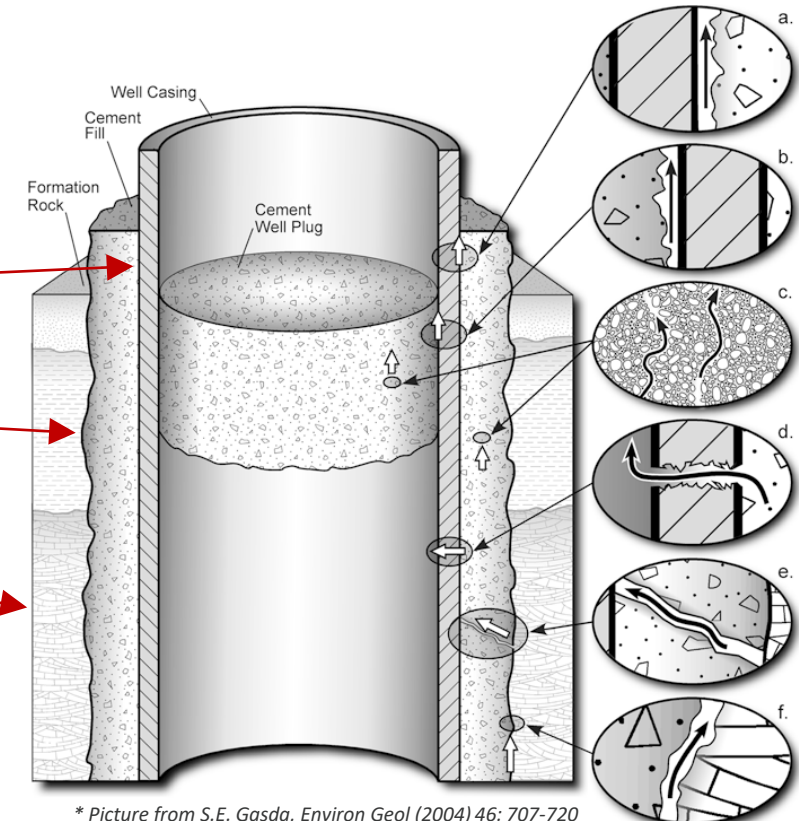
- System development for borehole integrity

- Physical process, improved methodology, technique or device.
 - All of the above (Develop a high-resolution 3D imaging **system** for improved wellbore diagnostics and integrity assessment)

- Expected outcomes and advancement of knowledge

— Extend applicability to:

- casing-cement interface
- cement-formation interface
- out in the formation



* Picture from S.E. Gasda, Environ Geol (2004) 46: 707-720

Project Background/Methodology

- Previous supporting research
 - Project evolved from “Seedling” to “Sapling” to this project

- Current state-of-the-art

- Either sonic probe (low resolution), or ultrasonic probe (low penetration)

- Project started:

- 2017

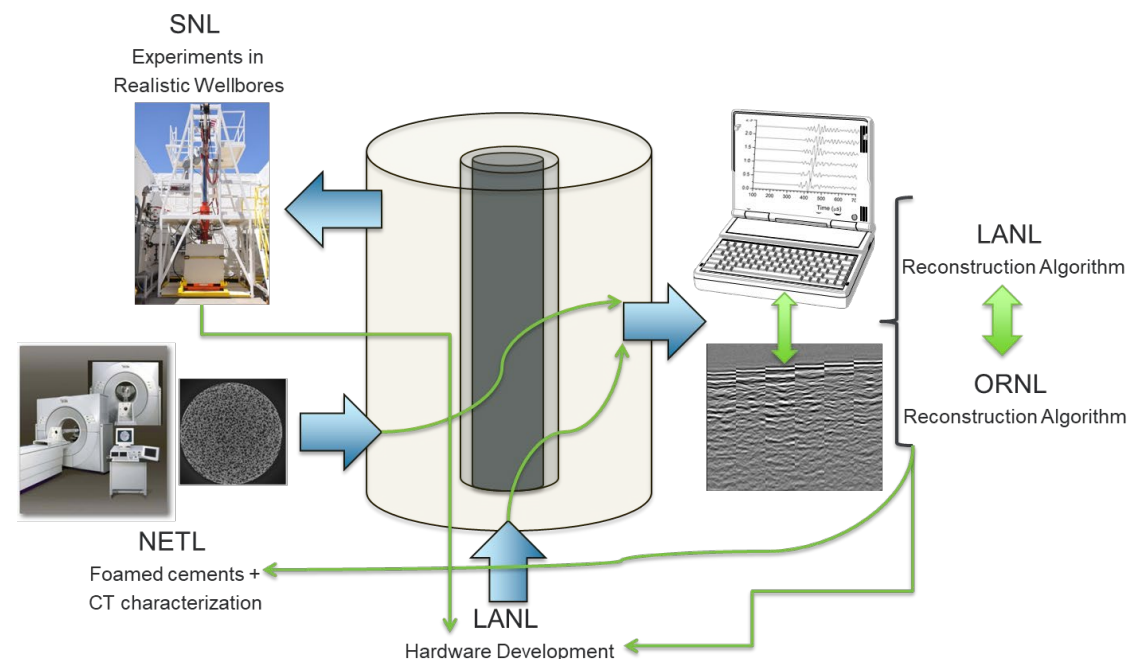
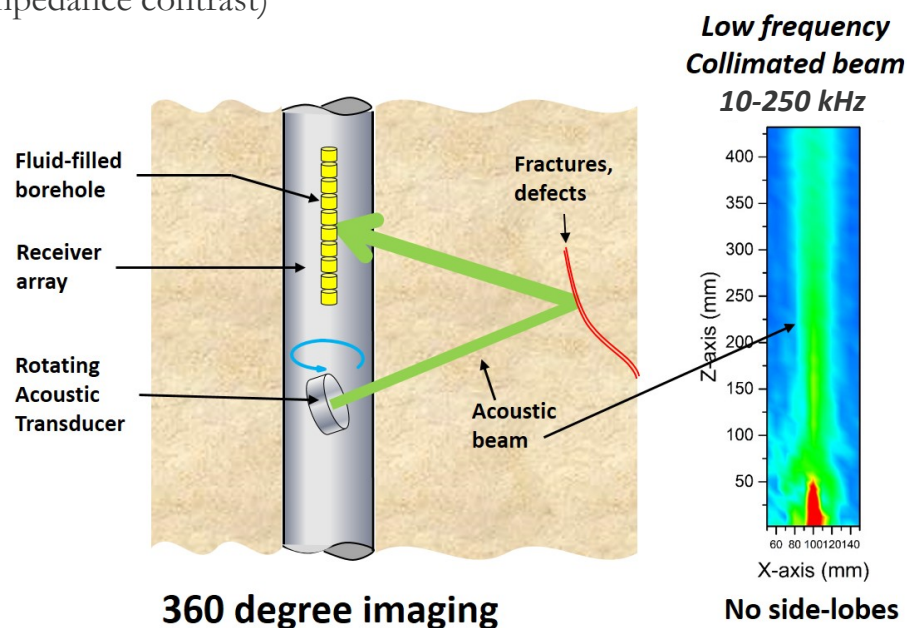
Comparison of existing techniques and the present approach

Method	Frequency (kHz)	Range (m)	Resolution (mm)
Sonic probe	0.3-8	15	~ 300
Present approach	10-150	~ 3	~ 5
Ultrasonic probe	>250	casing	4-5

Project Background/Methodology

• Methodology

- Use simple low-frequency collimated source in conjunction with receiver array to collect data beyond casing
- Use advanced signal-processing techniques and data inversion to reconstruct images
- Investigate use of foamed cements viability (conventional methods have difficulty detecting foamed cement due to low impedance contrast)

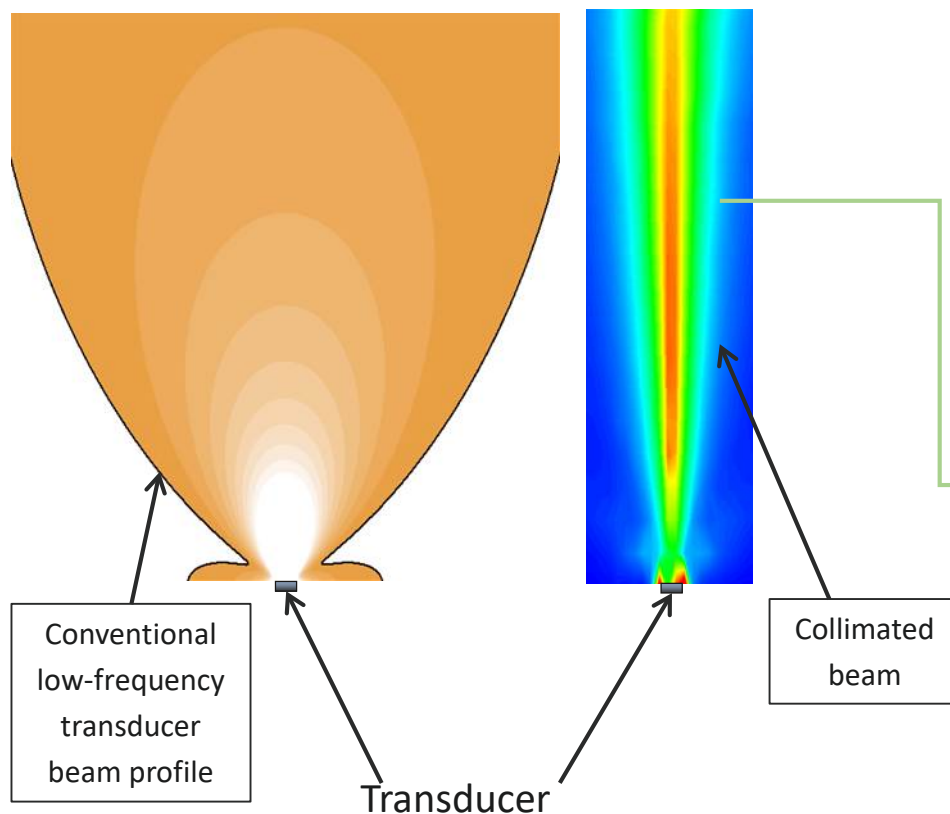


Technical Approach

Novel technique that fills technology gap

Method	Frequency (kHz)	Range (m)	Resolution (mm)
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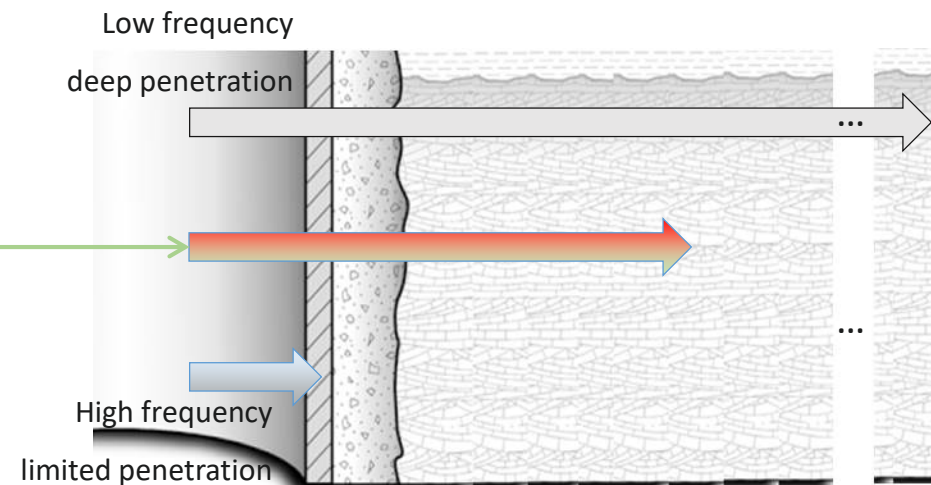
1. Collimated beam for increased resolution



2. Low frequency for deeper penetration

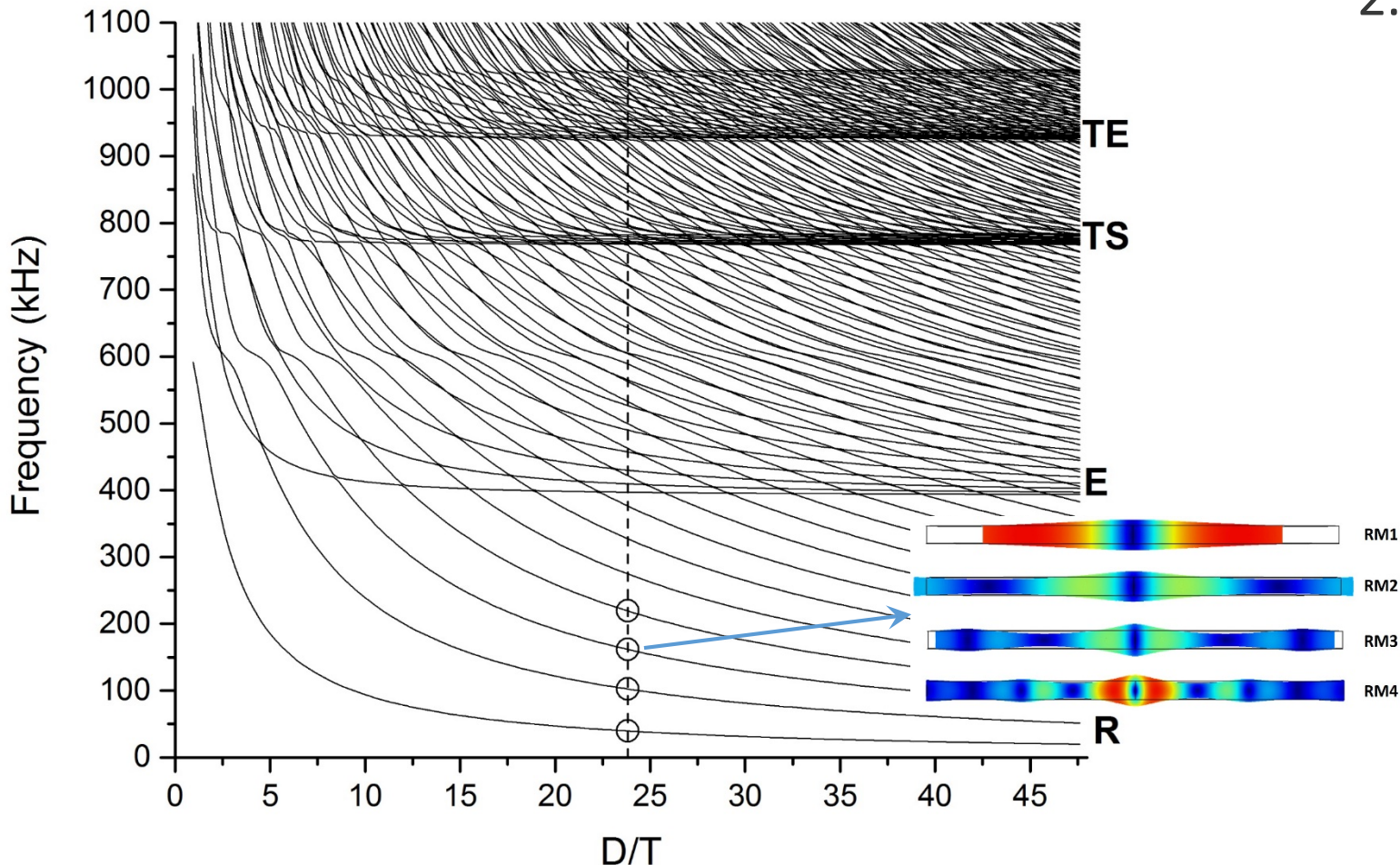
$$\text{Attenuation} \sim f^n$$

$$f = \text{frequency}, n = 1-2$$

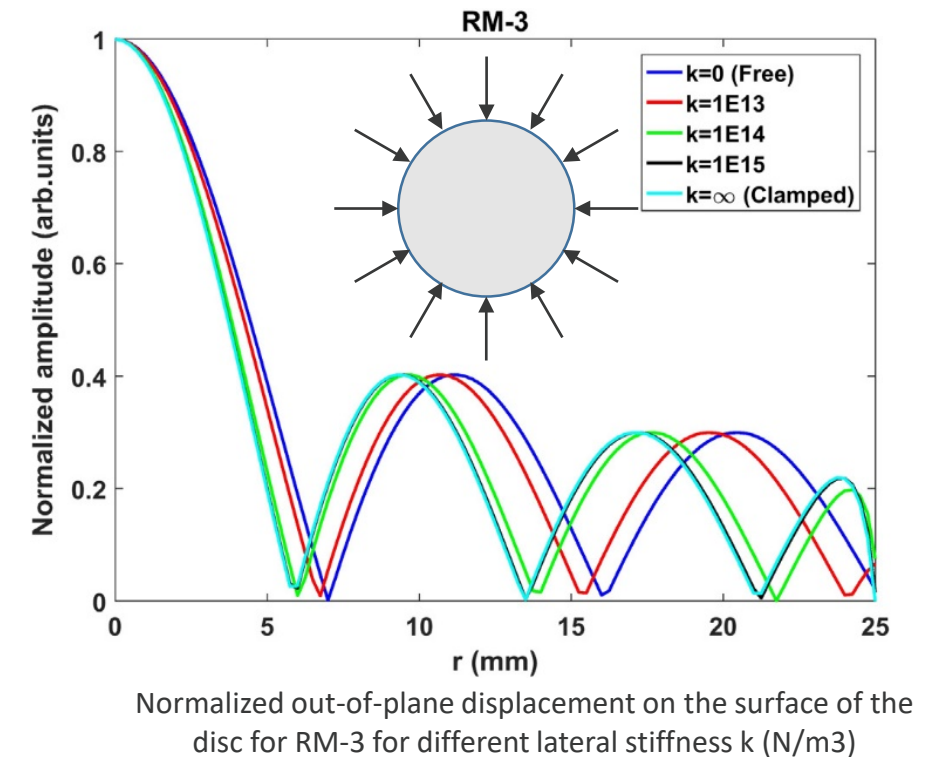


Technical Approach

1. Use radial modes to generate Bessel-like acoustic beams



2. Laterally clamp transducers to alter boundary conditions



Technical Approach

- Include telemetry (i.e., details on how data is/will be transmitted)
 - Data will be transmitted through existing wireline

Accomplishments to Date

- Performed a comprehensive literature/existing technology study for wellbore integrity monitoring tools
- Identified potential partner for further developing the proposed technique
- Refined hardware (ACCObeam – Acoustic Collimated beam)
- Refined software for faster measurement and analysis
- Performed theoretical prediction on foamed cement Young's modulus with different hydration degrees
- Acquired data in granite with embedded defects (wall thinning, casing eccentricity, channeling, delamination)
- Pending data analysis for the above.
- Planning cementation of 4" casing in two samples of Mancos shale

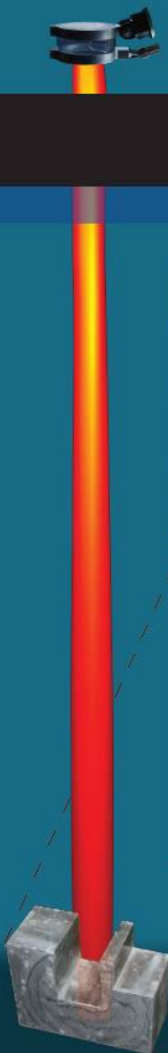

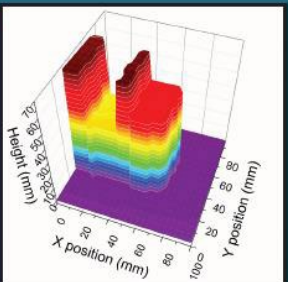
Accomplishments to Date

2018 R&D 100 FINALIST

ACCObeam:

Acoustic Collimated Beam

Precise, inexpensive monitoring of fractured rock, concrete, and metal

Cristian Pantea,
Dipen Sinha, and
Vamshi Chillara

- Collimated, powerful beam enhances image resolution
- Low-frequency beam for deep penetration
- Inexpensive and simple to produce
- Applications range from wellbore safety to biomedical imaging

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- Appl. Phys. Lett., 2018, v. 113, issue 7, p. 071903
- Wave Motion, 2018, vol. 76, p. 19-27
- Appl. Phys. Lett., 2017, v. 110, issue 6, p. 064101
- Proceedings of SPIE, 2017, v. 10170, p. 1017024
- 1 manuscript in preparation (sandstone characterization)
- 1 conference paper–Rock Mechanics
- 1 conference paper submitted –Nondestructive Evaluation
- 1 patent application (Resonance-based Nonlinear Source)
- 1 patent application (Bessel-like Acoustic Source)
- 1 provisional patent (Imaging Technique with Low-frequency Beam)

Lessons Learned

- **Describe any challenges and issues that have presented themselves.**
 - Research gaps/challenges.
 - Engineering issues with hardware packaging for experiments in granite
 - Unanticipated research difficulties.
 - N/A
 - Technical disappointments.
 - N/A
 - Changes that should be made next time.
 - Closer interaction with technical members of the team

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